LADEE UVS OBSERVATIONS OF SOLAR OCCULTATION BY EXOSPHERIC DUST ABOVE THE LUNAR LIMB. D. H. Wooden[1], A. M. Cook[2], A. Colaprete[1], M. H. Shirley[1], K. E. Vargo[2], R. C. Elphic[1], T. J. Stubbs[3], D. A. Glenar[4], [1]NASA Ames Research Center, Moffett Field, CA 94035, [2]Millenium Engineering & Integration Company, 350 North Akron Road Building 19, Suite 2080, Moffett Field, CA 94035, [3]NASA Goddard Space Flight Center, 8800 Greenbelt Rd, Greenbelt, MD, 20771, [4]University of Maryland Baltimore County, 1000 Hilltop Circle, Baltimore, MD 21250

Introduction: The Lunar Atmosphere and Dust Environment Explorer (LADEE) is a lunar orbiter launched in September 2012 that investigates the composition and temporal variation of the tenuous lunar exosphere and dust environment. The primary goals of the mission are to characterize the pristine gas and dust exosphere prior to future lunar exploration activities, which may alter the lunar environment. To address this goal, the LADEE instrument suite includes an Ultraviolet/Visible Spectrometer (UVS), which searches for dust, Na, K, and trace gases such as OH, H_2O, Si, Al, Mg, Ca, Ti, Fe, as well as other previously undetected species. UVS has two sets of optics: a limb-viewing telescope, and a solar viewing telescope. The solar viewer is equipped with a diffuser (see Figure 1a) that allows UVS to stare directly at the solar disk as the Sun starts to set (or rise from) behind the lunar limb. Solar viewer measurements generally have very high signal to noise (SNR>500) for 20-30 ms integration times. The 1-degree solar viewer field of view subtends a diameter of ~8 km at a distance of 400-450 km.

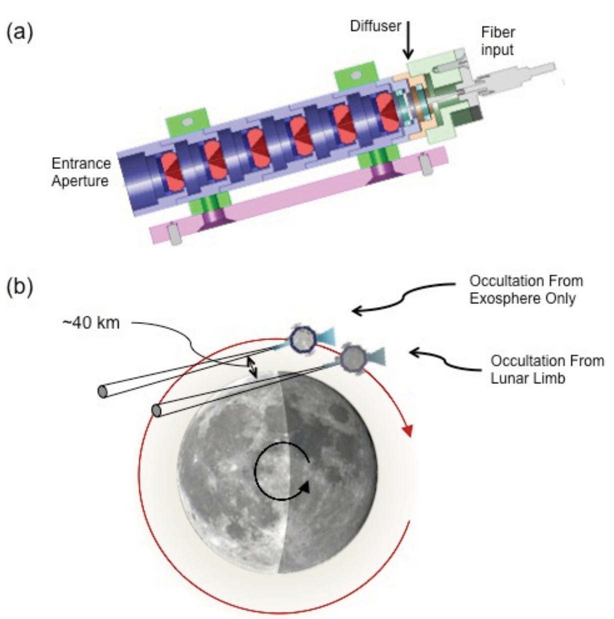

Figure 1. (a) UVS solar viewer foreoptics, showing six sequential baffles, which define the field of view and minimize the contribution from off-axis scattered light. The solar diffuser is shown just before the fiber optic input, which leads to the spectrometer. (b) Cartoon of a UVS occultation activity, showing the solar viewer field of view cone grazing the lunar exosphere, and then the lunar limb, as LADEE's orbit progresses through local sunrise.

Occultation Measurements: Figure 1b shows a schematic of LADEE in lunar orbit during a solar occultation measurement. Solar occultation observations are captured at the lunar sunrise limb, as the LADEE spacecraft passes into the lunar night side, facing the sun (the spacecraft orbit is near-equatorial retrograde); each activity of this type captures approximately 1650 spectra. Spectral collection begins when the solar viewer field of view grazing point is ~40 km above the lunar surface. UVS then continues to collect spectra with the solar viewer pointed directly at the sun, sampling progressively lower altitudes. Sampling continues as the solar disk is partially and then then totally occulted by the lunar limb. For this work, UVS occultation measurements for solar viewer fields of view grazing altitudes spanning ~30 - 0 km above the ter-

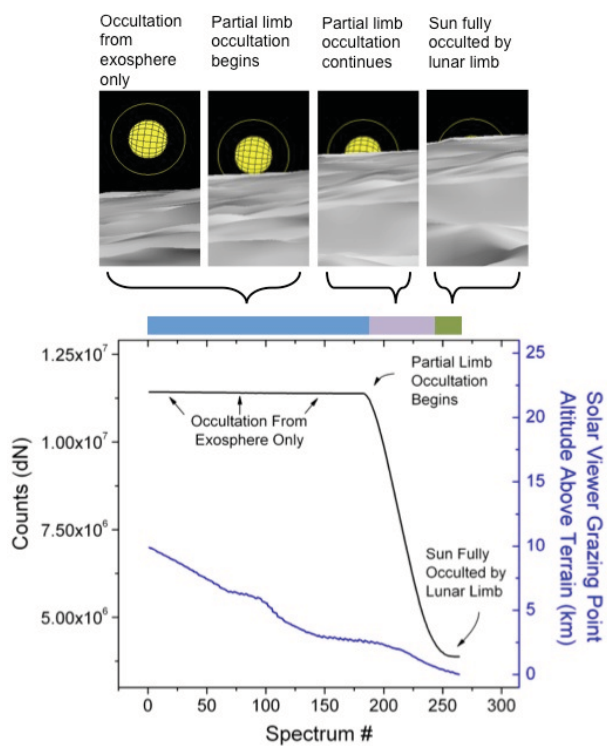

Figure 2. A light curve from an example occultation activity, annotated with cartoons of the Sun as seen from the UVS solar viewer. The yellow line around the Sun in each cartoon marks the solar viewer field of view. Each view corresponds to a different section of the solar occultation light curve.

rain, are analyzed for the signatures of extinction by lunar exospheric dust.

Figure 2 shows a light curve that illustrates the progression of a single occultation measurement activity. Viewed at maximum scale (total counts in each spectrum, integrated between 230 and 810 nm, in Digital Number or dN), the light curve appears to be flat at the top, with a sharp drop-off later in the activity. This drop-off in total brightness is due to the solar disk being increasingly occulted by the lunar limb. However, the apparently "flat" top of the light curve actually exhibits structure as the solar viewer field of view passes through progressively lower altitudes above the surface. It is this section of an occultation activity – the portion where the solar disk is not yet occulted – that is the focus of this particular study. Occultation measurements from 20 or more different orbits will be presented.

Results: For our analyses, two spectra (I_o and I) are chosen for each occultation activity. I_o comes from solar viewer measurements at an early time in the activity, at ~30 km solar viewer field of view grazing point altitude. Spectrum I comes from solar viewer measurements at a late time in the activity, at ~1 km solar viewer field of view grazing point altitude. A spectral ratio (I/I_o), which defines the transmission between these two time points (and, correspondingly, field of view altitudes), is then derived to search for wavelength-dependent absorption or wavelength-dependent forward scattering. Given the expected small line-of-sight abundance of lunar exospheric dust, the optical depth τ, defined by $I/I_o = \exp(-\tau)$, can be approximated by $1-\tau$ with no loss of accuracy. Optical depths of $\sim 10^{-3}$ can be sought in the spectral ratios by examining the transmission I/I_o in 50-nm-broad bandpasses, i.e., after performing a weighted sum of spectral points outside of the Fraunhofer lines and over ~50 nm wavelength intervals.

Our preliminary results indicate wavelength-dependent extinction as a function of altitude. We attribute the detected spectral color changes to the presence of sub-micron sized dust grains in the lunar exosphere. Details of these results will be presented, and compared to previous models[1], [2] of the lunar dust exosphere.

References:

[1] McCoy J. E. (1976) *Proceedings of the 7th Lunar Science Conference*, 1087-1112 [2] Glenar D. A. et al. (2011) *Planet. Space Sci.,* 59, 1695-1707.